

CLAIMS

1. A vibration linear actuating device comprising a vibrating linear actuator and a driver for driving the actuator;

5 the vibrating linear actuator including:

(a) a mover having a permanent magnet magnetized in a radial direction;

(b) a stator having a coil and facing the permanent magnet;
and

10 (c) an elastic body for coupling the stator to the mover and energizing the mover toward a center of the stator,

the driver including:

(d) a driving section having a switching element for powering the coil;

15 (e) an output controller for controlling the switching element;
and

(f) a zero-cross detector for detecting a zero-cross point of back electromotive force (BEMF) generated in the coil and outputting a zero-cross signal,

20 wherein the driver transmits the zero-cross signal to the output controller and powers the coil in one direction for vibrating the mover in corporation with the elastic body.

2. The vibration linear actuating device of claim 1, wherein the driver
25 further includes a zero-cross monitor disposed between the zero-cross detector and the output controller.

3. The vibration linear actuating device of claim 2, wherein the zero-cross monitor monitors the zero-cross signal and does not permit receiving a next zero-cross signal for a given time after the monitor receives the zero-cross signal.

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4. The vibration linear actuating device of claim 1, wherein the driver transmits a re-starter signal to the output controller when the zero-cross signal is halted for a given time.

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5. The vibration linear actuating device of claim 1, wherein the zero-cross detector is coupled to the coil via a BEMF amplifier and a level-shift section.

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6. The vibration linear actuating device of claim 1, wherein the driver further includes a timing adjuster disposed between the zero-cross detector and the output controller.

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7. The vibration linear actuating device of claim 6, wherein the timing adjuster includes a phase locked loop.

8. The vibration linear actuating device of claim 1, wherein the output controller includes a pulse width modulator.

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9. A method of driving an vibrating linear actuator, the actuator comprising:

a mover having a permanent magnet magnetized in a radial direction;

a stator having a coil and facing the permanent magnet; and
an elastic body for coupling the stator to the mover and
energizing the mover toward a center of the stator,

the method comprising the steps of:

5 (a) determining a zero-cross point of back electromotive force
generated in the coil;

(b) determining a period for powering the coil in every cycle;

(c) determining a period for powering the coil at starting time;

and

10 (d) counting step (b) based on the determined result of step (a).

10. The method of driving an vibrating linear actuator of claim 9
further comprising step (e) for counting for itself based on the determined
result of step (a), wherein the determined result of step (a) is kept invalid
15 until step (e) counts up.

11. The method of driving an vibrating linear actuator of claim 9
further comprising step (f) for counting for itself based on the determined
result of step (a), wherein step (c) starts counting when step (f) counts up.
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12. The method of driving a vibrating linear actuator of claim 11,
wherein step (f) is reset depending on a next determined result.

13. A portable information apparatus comprising:

25 (a) a board;

(b) a vibrating linear actuator mounted to the board; the
actuator including:

(b-1) a mover having a permanent magnet magnetized in a radial direction;

(b-2) a stator having a coil and facing the permanent magnet; and

5 (b-3) an elastic body for coupling the stator to the mover and energizing the mover toward a center of the stator,

(c) a driver mounted to the board, the driver including:

(c-1) a driving section having a switching element for powering the coil;

10 (c-2) an output controller for controlling the switching element; and

(c-3) a zero-cross detector for detecting a zero-cross point of back electromotive force (BEMF) generated in the coil and outputting a zero-cross signal,

15 wherein the driver transmits the zero-cross signal to the output controller and powers the coil in one direction for vibrating the mover in corporation with the elastic body.

14. The portable information apparatus of claim 13, wherein the
20 vibrating linear actuator generates vibrations with a maximum amplitude in a vertical direction to the board.

15. The portable information apparatus of claim 13, wherein the
driver further includes a zero-cross monitor disposed between the zero-cross
25 detector and the output controller.

16. The portable information apparatus of claim 15, wherein the zero-

cross monitor monitors the zero-cross signal and does not permit receiving a next zero-cross signal for a given time after the monitor receives the zero-cross signal.

5 17. The portable information apparatus of claim 13, wherein the driver transmits a re-starter signal to the output controller when the zero-cross signal is halted for a given time.

10 18. The portable information apparatus of claim 13, wherein the zero-cross detector is coupled to the coil via a BEMF amplifier and a level-shift section.

15 19. The portable information apparatus of claim 13, wherein the driver further includes a timing adjuster disposed between the zero-cross detector and the output controller.

20 20. The portable information apparatus of claim 19, wherein the timing adjuster includes a phase locked loop.

20 21. The portable information apparatus of claim 13, wherein the output controller includes a pulse width modulator.